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GROUP CHARACTERISTICS OF ANALOGS

L. A. Vitel's

In the method used by the Mul'tanovskiy school, analogs are selected by successive elimination of unsuitable years to isolate one best analog. Of the several good analogs found with respect to history, i.e., with respect to processes and weather characteristics of past seasons, only those are left which are marked by processes developing in 3-month, 5-month and, recently, in 4-month periods; the so-called datum-point systems.

If two or more analogs are selected in which all datum-point systems obtain, processes in the intervals between these systems are compared. If these intermediate processes in all analogs develop analogously, which is highly improbable, the character of development of atmospheric processes between the two basic circulation mechanisms is interpolated simply with the help of analogs," according to (T. A. Duletova, S. T. Pagava, A. A. Rozhdestvenskiy, and N. A. Shirkin, in their Principles of the Synoptic Method of Long-Range Weather Forecasts, edited by S. P. Pagava, Leningrad/Moscow, 1940). If these intermediate processes are not analogous, the analogs are again inspected, the indications obtained from periods and phases are again checked, and there is a more accurate weighing to determine which analog "prevails"; the forecast is based on this analog. Diagrams of atmospheric processes and weather characteristics are practically copied from this good analog and only occasionally "corrected" in some details on the basis of the datum-point systems or other considerations.

Thus, the method described for selecting analogs is based on very detailed comparison to select one best analog. With this selection method, an analog assumed as the best often differs from other analogs in very insignificant details; nevertheless, these details are the "makeweight" which forces the forecaster to use this analog.

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This makeweight, not very important in itself, often has important consequences. For example, a certain analog with very low temperatures is selected, but the other analogs show warm weather; heavy precipitation is forecast from the analog selected, but the other analogs not selected indicate no precipitation at all. In short, when the weather is copied down from one analog, all the individual characteristics of this analog are included in the forecast regardless of whether or not these characteristics conform to other analogs.

We question the importance of these details which are used to select one out of all the analogs to arrive at one definite variation out of a number of possible variations in the future development of weather. We are well aware that even the best analog may in time depart so far from reality that the weather becomes directly opposite to that forecast and that an analog that was very poor in the past and disregarded in drawing up the forecast often becomes closest to reality later. By selecting one analog, we give too much weight to its individual characteristics.

By forecasting all these characteristics from one analog, we drift into a position of extreme determinism that borders on fatalism. By copying the weather from one analog, we consider both large-scale processes and fine details predetermined and actually have no basis for limiting the forecast to an arbitrary degree of details. The formulation and "detailization" of forecasts for various periods prescribed by the instructions are established arbitrarily and have neither theoretical nor practical bases.

We laugh at the forecasts of Bryusov's almanac and a daily description of weather many years in advance, but we consider forecasts quite legitimate in which a very detailed weather description is given 2 or 3 months in advance for individual regions and for time intervals of several days, with average diurnal extremal temperatures given within 2 or 3°, winds given with intensity within 1-2 /Beaufort scale/, etc. What basis do we have for such fine detail? What should and should not be copied from an analog? How can this problem be solved?

By assuming a causal relation between natural phenomena and the existence of regularly developing atmospheric processes, we legalize lone-range synoptics as a science. In other words, we consider that when we give a forecast we have sufficient grounds for predetermining various events in the atmosphere. The crux of the matter lies in establishing how detailed the forecast can be without being drawn into a "predetermination" of events which enters into metaphysical determinism. Very descriptive characteristics of the latter were given by Engels in Dialectics of Nature, p 175, 1946: "According to this outlook, only a simple direct necessity predominates in nature, etc. ..." /one-paragraph quotation from Engels omitted/.

If we accept fate, we can actually forecast anything we want to, without worrying about establishing any sort of limits on time or detail of forecasts. If we stick to a strictly scientific outlook, we must, before we start to draw up a forecast on the basis of a certain method, know exactly the potentialities of this method, the actual probability of justification of forecasts for various times in advance, and the permissible limits of details. If we do not know these things, it is difficult to draw the line between a scientific forecast and guesswork. Unfortunately, the present-day method of long-range weather forecasting has not solved this basic problem and has not even considered it. Forecasts are given, but why they are given in such formulations, and in such detail with respect to the elements in time and in space, in unknown.

In many cases, the reason for making forecasts more detailed or giving them for longer periods in advance is due not to improvements in method, but to the demands of the consumer, for the analog method permits us to "detailize" and elaborate the forecast as much as desired by simply copying from the analog.

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To end this state of affairs and establish the problem of long-range weather forecasts on a firm scientific basis, we must first of all accept that the time (in advance), formulation, and degree of detail of forecasts cannot be established arbitrarily but must follow from the very nature of the macro-process on which the forecast is based. The forecast should not give what is not connected with the process, whose inception or development is observed in drawing up the forecast.

Weather is determined by processes of different scope. To predict 2 months in advance phenomena or weather details which are determined by processes lasting several days or even several hours is simply to engage in a guessing game. For example, let us assume that our task is to forecast floods in Leningrad. The main cause of the latter are the cyclones which pass slightly north of the Gulf of Finland, accompanied by strong west winds.

The development of cyclonic activity in northwestern Europe and over the Baltic Sea can be given even in a seasonal forecast. In a forecast for a month in advance, the predominant type of cyclone trajectories and, in some case, the most dangerous periods can be defined. In a forecast for a natural synoptic period, the paths of cyclones can be made more accurate, but in this forecast only approximate indications can be given of flood danger. Even for 24 hours in advance, it is still impossible to give a definite flood forecast. We can speak of the concrete danger of a flood only when the flood cyclone is already present, and often it forms only on the very day of flooding. Obviously, a quantitative forecast can be given with good reliability only for several hours in advance. Since many meteorological and hydrological factors are closely interwoven in the flood mechanism, the direction and operation of which become apparent only when the water begins to rise. We will be able to say accurately what should be given in our forecasts only when we understand the laws of development of the flood process.

The same applies to other atmospheric processes.

Does this mean that at the present stage of meterology we lack a scientifically based approach to the problem of the permissible limits of detail in forecasts? We believe that something can be done in this direction right now.

It is, of course, possible to solve the problem purely empirically from the correlation coefficient of forecasts for various periods in advance and different amounts of detail. Such approval of forecasts for current material would require repeated experiments and in checking the method of long-range forecasting for long periods in advance, the result would become clear only after many years, when sufficient material had accumulated for statistical processing.

Processing of material for past years would be more effective. Approval of a method based on this material would be absolutely compulsory. This work is very labor-consuming, but without it not one of the empirical methods used at present can determine the real correlation coefficient of forecasts of varying detail for various periods in advance. Unfortunately, such checking of methods used for meteorological forecasts has not been initiated, although it has long been general practice in hydrological forecasts.

One more fact which is usually ignored must be taken into consideration in determining the real possibilities of a method, i.e., the fact that the correlation coefficient of forecasts is not constant, but depends on the nature of the process. In each individual case we have a set of concrete conditions which determine the degree of "detailization" of the forecast, which degree for a given time in advance will guarantee that errors beyond the established limits will not occur.

There are cases where a process that is used as a basis for a forecast is expressed very sharply and uniquely and has sufficient and quite definite intensity without permitting any substantial deviations. Clearly, the forecast can be made more accurate with greater "detailization" in time and space in these cases.

There are also cases, however, where from the very beginning a process develops sluggishly, with obscure characteristics and insufficient spatial localization of various effects, or where several variations of the future development of the process are equally probable.

In these cases, we must obviously restrict ourselves to more general formulations, since we do not have sufficient grounds for making the forecast very accurate.

There might even be cases where the material available to the forecaster does not permit any definite decision. If there is no basis for a definite forecast, it should not be given.

Unfortunately, this seemingly elementary truth is not universally acknowledged in synoptic practice. This applies to some extent to short-range as well as to long-range forecasts. The instructions prescribe for all actual cases definite time-in-advance forecasts, with definite gradations of the forecast quantities. The short-range synoptic meteorologist is often forced to change from objective considerations and calculations to personal intuition to accept this or that solution; the long-range synoptic meteorologist simply copies everything that is required from the analog without caring how reasonable this copying is. The synoptic meteorologist, not having a definite criterion other than the instructions, easily loses an intelligent feeling of proportion in the use of analogs.

To judge the correlation coefficient characteristics taken from the analog and to establish intelligent limits in the use of analogs in each practical case, we must change from the individual properties of one (even the best) analog to the group characteristics of several analogs.

This is the basic difference in our method of using analogs from that accepted in the Central Forecasting Institute.

Our approach to analogs is distinguished by the elimination of individual characteristics of separate analogs and the search for something general that characterizes all good analogs or most of them, plus emphasis on those properties which become more intense for increasing analogousness and which weaken or drop out for low analogousness.

For this purpose, we have adopted three systematic methods of processing analogs:

1. Construction of the group characteristics of the best analogs

2. Study of "counteranalogs."

3. Study of the behavior of individual meteorological elements in analogs, depending on the degree of analogousness.

The group characteristics of analogs can best be constructed by drawing up all possible composite maps. The term "composite maps" is understood in its widest concept here, ie., as maps reflecting the characteristics of a whole group of analogs. These include composite-statistical and composite-kinematic maps drawn up by the Mul'tanovskiy method, maps of the frequency or probability of various phenomena of the G. Ya. Vangengeym type, macrobaric maps of the author, and other similar maps which unite but do not average the

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characteristics of all analogs entering into the given group. Mean maps can also be used, but only as a supplement to those named above and not in place of them. Composite maps of the selected group of analogs give a group characteristic which emphasizes something common and inherent to all analogs in their subsequent development. These features, common to all analogs, reflect the most important characteristics of the macroprocess and must be used as the basis for forecasts. By restricting the forecast to a greater or less degree of reliability, we can add to the main characteristics that are common to all analogs those which are repeated in 90%, 85%, 80%, etc., of the analogs. By drawing up the forecast in this way, we always know which elements are more reliable and what degree of detail we can attempt without overstepping the circle of characteristics common to the entire group. At the same time, this method brings out the individual characteristics of the separate analogs, i.e., the possible, although less probable, variations which should be considered in drawing up the forecast as extreme deviations not common to but within the family of the best analogs. The spread obtained in this way is, as a rule, considerably narrower than the perennial amplitude of the element to be forecast and restricts the climatological data on the possible extremals to only those limits which can be observed under appropriate conditions.

The elements of the separate analogs stand out sharply on the general background, e.g., a cyclonic center in an anticyclone field of a composite map, trajectories passing contrary to the rest on a composite-kinematic map, etc. Thus, these analogs can be incorporated into a special group and considered separately.

When examining group characteristics of analogs, we may find cases where the maps, graphs, tables, and other material reflecting the properties of the entire group do not give a clear picture, i.e., do not show characteristics common to all or a majority of the analogs. This means that a definite unique solution for the given element cannot be derived and this element should either be left out of the forecast or the amplitude of its fluctuations in the given group should be given in full.

Although we have discussed the group characteristics of the best analogs, we have not yet touched upon the very important problem of which analogs should be accepted as best. It is evident that the solution of this problem will always be of an arbitrary nature. For objectivity, the indefinite term "best analogs" should be clarified in each separate case by an indication of the limits of analogousness of the given group of analogs. (See author's previous article "Method of Selecting Analogs in Long-Range Weather Forecasts," <u>Meteorologiya i Gidrologiya</u>, No 3, 1948.) From this standpoint, we can unite analogs with analogousness of at least 90%, at least 80%, etc., so that out of a total of 40-45 analogs in a given group, approximately one-half this number will drop out, i.e., about 10 analogs.

The frequency (in percent) of a certain phenomena can be calculated for a smaller number of analogs, but the less this number the less reliable will be the result. Ten cases is also very few, but for an entire 40-year series it would be inefficient to consider a larger group of best analogs, since it would be necessary to include analogs with lower analogousness and the common characteristics of the group would not stand out so clearly.

A few analogs can be used to construct composite-statistic and composite-kinematic maps. A restriction of 75% analogousness for construction of group characteristics can be recommended as a general rule, but when there are a sufficient number of analogs with high analogousness, this limit should be exceeded. When averaging is carried out for all regions and several characteristics are combined, the number of years with a high degree of analogousness usually decreases. In such cases, several maps should be drawn up, e.g., for analogs with analogousness less than 90%, less than 85%, less than 80%, etc.

Comparison of these maps will show which characteristics of the analogs stand out sharpest with increase in analogousness. These characteristics are obviously the most reliable and the forecast should be drawn up mainly from them.

The stage following the construction of the group characteristics of the best analogs is the construction of similar characteristics for the poorest analogs, i.e., for those years with lowest analogousness or low values of divergence in the series under study. We call these years counter-analogs. Group characteristics of counteranalogs are constructed by the same methods as for the best analogs. The upper limit of analogousness used to limit the group of counteranalogs depends on the number of counteranalogs with various degree of analogousness. If the comparison year lies close to the extreme, the degree of analogousness in the opposite series of years around the other extreme will be small and the group of counteranalogs can be limited to those with low analogousness. If the comparison year belongs to the normal with respect to the given characteristic, i.e., if the comparison values of the given element are close to the mean perennial values, the poorest analogs should not be incorporated into one group, but should be divided into two groups with positive and negative deviations and the group characteristics constructed separately for each group.

The group characteristics of the best analogs reveal the common features that result from the analogousness of the processes of each of these analogs to processes of the comparison year; whereas the group of counteranalogs, however, generally shows the reverse, i.e., the absence of these characteristics or their marked weakening.

The opposite nature of group maps, graphs, tables of values, etc., of counteranalogs, in comparison with group characteristics of the best analogs, increases the reliability of the latter. Comparison of the group characteristics of the best analogs and counteranalogs will isolate from the entire set of characteristics those which are closely connected with analogousness.

Having found that a given element has, for example, high positive deviations from the norm for high analogousness and high negative deviations for low analogousness, we can move on to further testing of analogs by comparing the values of the given element with the analogousness for the whole series of years. If this comparison reveals a definite regularity of the variations of the given element when the analogousness increases or decreases, we can estimate the values to which the given element would tend for 100% analogousness and use these in drawing up the forecast.

Thus this test would indicate the connection of the given element with analogousness and, in a number of cases, would permit a quantitative instead of a qualitative forecast.

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